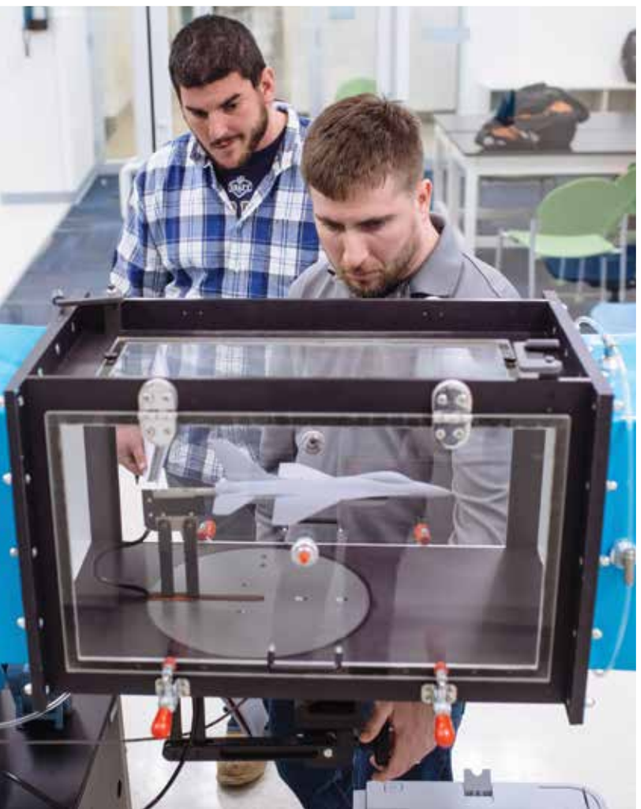
ENGINEERING Momentum

Across Disciplines. Across the World® // **SPRING 2016**

Washington University in St. Louis

Snapshot //

The Aerolab Educational Wind Tunnel can measure the drag force on an F-16 model airplane wing with slats and flaps or a sphere. It can also measure the pressure distribution around an airfoil (like an airplane wing) to calculate the lift force as well as the pressure distribution around a cylinder.



PHOTOS BY WHITNEY CURTIS

From the Dean //

Dean Aaron Bobick at his installation as the James M. McKelvey Professor

Dear friends,

Though it feels like barely a couple of months, I have been Dean for an entire academic year, and while I may not be able to completely catch my breath, I now have more perspective on the strengths of our school and how we might attack the challenges ahead.

Let me start with our absolute best: our undergraduate students. Having spent time at MIT, Stanford and Georgia Tech, I know that I can put our students up against any of them. It is not just their raw intellectual horsepower — it goes without saying they have the natural ability to attack any problem, and it is their *depth* I find remarkable. They not only take on challenging majors, but many of them double major to expand their horizons while participating in organizations that help to change the world and still taking time to express themselves, such as singing with the spectacularly accomplished a capella groups here at WashU. Some of our students work as mentors and teaching assistants within community-based learning programs such as LaunchCode described at the end of this edition. You will read about some highlighted individuals in these pages, but I can tell you, our halls are filled with such students.

Of course, it is the faculty who actually do the work. At a research university, faculty must focus on both creating knowledge that advances the state of the art of their domains as well as educating the next generations of scholars and citizens. While we have numerous faculty pushing in both of these directions — read about the advanced work on connected devices (aka the Internet of Things) and research in computer science education — one our biggest challenges is to grow the faculty in important research domains that will impact the world over the next several decades. I am thrilled that our junior faculty — almost one-third of the faculty have been at WashU fewer than five years — are doing remarkably well, winning prestigious research grants and awards that attest to their innovation and contribution.

Finally, I find the dedication of our alumni inspiring. After 16 years at a university where much of alumni engagement involves reminiscing about football national championships, it is refreshing to hear from alumni who share a passion for the mission of the school, producing both people and knowledge poised to change the region, the country and the world. Your support of both time and resources allows us to pursue excellence in all dimensions: scholarships to enable talented students to attend, endowed professorships that allow us to attract thought leading researchers, mentoring to inspire and connect our students and facilities that are world class. You make this happen.

Onward…

Aaron F. Bobick
Dean & James M. McKelvey Professor
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SPRING 2016

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Engineering Momentum is published by the School of Engineering & Applied Science at Washington University in St. Louis. Unless otherwise noted, articles may be reprinted without permission with appropriate credit to the publication, school and university.

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THE BUZZ #WashUengineers

Chamillionaire, Mark Suster visit WashU to discuss tech startups

Chamillionaire (left), a Grammy award-winning rapper and successful entrepreneur, and Mark Suster, a partner at Upfront Ventures, the largest venture capital firm in Southern California, visited WashU April 14. The pair recorded an episode of the webcast "Bothsides TV" with WashU students as the audience.

#WashUengineers alumni Mike and Cheryl Perlmutter.

Now in Urbauer Hall at #WashU #washureunion

Professors Viktor Gruev and Spencer Lake were included in a National Geographic Channel Explorer episode called "Explorer: Eyes Wide Open" that aired Feb. 14.

in the news

Bloomberg

ZACHARY FEINSTEIN

ON THE ECONOMICS OF "STAR WARS"

"The most surprising result was how large the economic collapse could be. Without a bailout, there was a non-negligible chance of over 30 percent drop in the size of the Galactic economy overnight — larger than the losses from the Great Depression over four years (from peak to trough)."

The New York Times

DANIEL GIAMMAR

ON THE FLINT, MICH., WATER CRISIS

The lead issues should have been anticipated long before the city switched water supplies, experts said. "I think that's pretty obvious, in going from having a corrosion inhibitor to not having one, you might have expected to have increased corrosion."

Bobick installed as James M. McKelvey Professor

From left: John F. McDonnell, Aaron F. Bobick and James M. McKelvey

Aaron F. Bobick, dean of the School of Engineering & Applied Science, was installed as the James M. McKelvey Professor Jan. 21.

Bobick joined Washington University in St. Louis July 1, 2015. Prior to Washington University, he was a professor and founding chair of the School of Interactive Computing at the Georgia Institute of Technology, where he had been a member of the faculty since 1999.

"Aaron Bobick is the perfect person for this professorship honoring longtime dean Jim McKelvey," said Chancellor Mark S. Wrighton. "We are especially grateful for the continued generosity of longtime friend and Trustee John McDonnell, who understands the importance of engineering and interdisciplinary education and is committed to ensuring the growth of the School of Engineering & Applied Science."

The James M. McKelvey Professorship is named in honor of McKelvey, who was dean of the School of Engineering & Applied Science from 1964 to 1991. It is one of three professorships established in 2003 with a gift from the JSM Charitable Trust and from John F. McDonnell, retired chairman of the board of McDonnell Douglas Corp.

COURTESY PHOTO

Engineers Without Borders completes final project in long-term partnership

For the Engineers Without Borders student group at Washington University in St. Louis (EWB-WU), service means more than simply helping those in need. It goes beyond that to create long-term partnerships that lead to sustainable change.

For five years, the students of EWB-WU have traveled to Ethiopia to work with their partners at the Mekelle School for the Blind. The school serves roughly 80 blind children in the region and is one of only a few like it in the country.

When the team first arrived in Mekelle in 2011, they found a vibrant community, passionate educators and bright students, who were struggling with the realities of living and operating in a developing city. Isolated on the outskirts of the city, the school had unreliable access to water and electricity, poor sanitation and inadequate resources to keep the school grounds secure.

With these in mind, the team started to tackle them, one at a time, by enlisting the help of local individuals and organizations. The students started by addressing the school's need for a reliable water source. Although the school had a connection to city water, it would often stop flowing for days or even weeks at a time. To solve this, the team went to work on stabilizing an old water tower and placing two 1,000-gallon reserve tanks on top. In two weeks, they completed the project with the help of local construction workers and a group of engineering students from a nearby university.

Using this model of collaboration, the team returned each year for two weeks to lay piping for the new water tower, improve the electrical grid at the school and assess the issues of stormwater and security. To ensure that each project would help the local economy, the team sourced all of its materials from local suppliers.

In January 2016, the team traveled to Mekelle to implement its final project. The previous trip allowed the students to assess a causeway that connects the student dormitories to the school buildings, a path that floods with 6 to 24 inches of contaminated water every year during the rainy season. With the help of local contractors, the students deepened the trench that channeled water toward the causeway and cleared the drains beneath the causeway to increase the flow of stormwater.

Written by Gennafer Barajas

JERRY NAUNHEIM JR.

Startup Connection 2015

Gaurav Garg, a founding partner at Wing Venture Capital and 2014 Silicon Valley Venture Capitalist of the Year, was the keynote speaker at Startup Connection 2015 held at WashU.

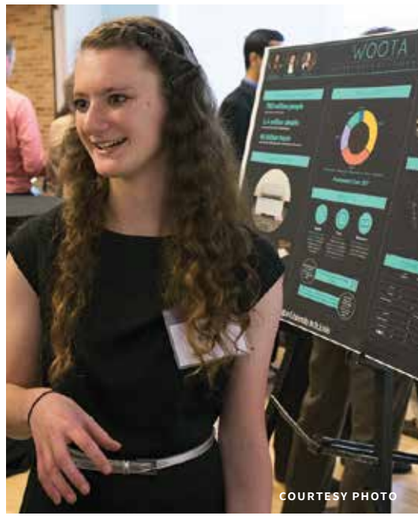
More than 1,200 attendees learned about 70 companies, including 25 founded or supported by Washington University alumni, faculty and students.

WashU hosted the St. Louis region's largest event focused on innovation and entrepreneurship, Startup Connection 2015, Nov. 18. The event included a venture showcase with 70 top early-stage startups, an elevator pitch stage, a resource fair with 60+ entrepreneur resource organizations that specialize in working with early-stage companies and Accelerate St. Louis Challenge awards worth $120,000.

Clean water project takes top prize in Discovery Competition

Nearly 1 billion people do not have access to clean water, but the winners of this year's Discovery Competition hope to solve that problem by literally creating Water Out Of Thin Air. WOOTA discovered a way to turn moisture from the air into a clean source of drinking water. With the first-place finish, WOOTA received a $20,000 cash prize and $5,000 in legal services from law firm Polsinelli. In second place, InVitro SELECT, which provides an innovative selection system for assisted reproductive procedures such as in-vitro fertilization, received $15,000 in cash and $5,000 in legal services from Polsinelli. Hidden Hand, a device that aims to improve the management of bleeding during surgery, took third place and received a $5,000 cash prize.

The School of Engineering & Applied Science launched the Discovery Competition in September 2012 to promote new and innovative discoveries to solve challenges or needs. The competition provides engineering undergraduate students the forum to explore their entrepreneurial interests with support from mentors, to use their creativity to develop solutions for real-world problems and to compete for financial resources that could help turn their ideas into businesses. The competition is an annual event funded by engineering alumni. Teams were composed of currently enrolled WashU undergraduate students, with at least one engineering student and at least one nonengineering student on each team.



COURTESY PHOTO

Women in STEM Day: Busting the ‘bro code’

Two high school students participate in a design challenge at the 2016 Women in STEM Day.

When Rebstock Hall was built in 1927 on the campus of Washington University in St. Louis, it did not have any women’s restrooms. Why would it? The building served the biology department, and biology was for boys.

Some 90 years later, women study the biological sciences at a higher rate than men. Still, when it comes to many STEM fields, the gender gap persists.

“There is a ‘bro code’ that is hard for women to bust through,” said Amritha Gourisankar, a junior in biomedical engineering at the School of Engineering & Applied Science. “The challenges for female scientists are real. But the opportunities and rewards are real, too.”

Gourisankar and Connie Gan, a junior in biology and mathematics, both in Arts & Sciences, shared those opportunities with female high school students at Women in STEM Day Feb. 27 at Washington University.

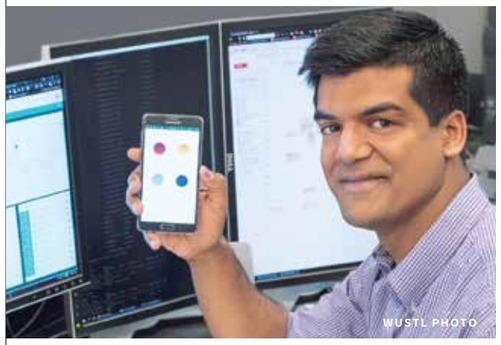
The event showcased cutting-edge science and top speakers. Highlights included a chemistry flame test, a 3-D printing demonstration, an introduction to environmental nanochemistry, and a competition to build an “earthquake-proof” structure from uncooked spaghetti, coffee stirrers, Play-Doh and other materials. Some 125 young women from across the St. Louis region attended.

“We show them the entire spectrum,” Gan said. “They learn not only about STEM majors, but all of the opportunities to further pursue their passions outside of class.”

The event was formerly known as Women in Engineering Day, but organizers changed the name to reach a wider audience. Also, many students don’t know that they are interested in engineering until they see it.

Written by Diane Toroian Keaggy

Stressed? There’s an app for that



After learning that local veterans were facing long waits for mental health services, a team of medical and engineering students at WashU wanted to help in some way.

The team created what its members hope will be an aid to veterans and others experiencing stress: an app that measures a user’s stress and suggests steps to take to alleviate it.

MD/PhD student Ravi Chacko (above) and biomedical engineering graduate Elizabeth Russell threw themselves into converting a good idea into a marketable product. They co-founded a company, obtained $250,000 in funding from private investors and brought social worker Cara Jacobsen, a Saint Louis University alumna, on board to direct clinical operations. The app, called Mindset, is now available for Android and is in beta testing for iOS.

“We found there weren’t many tools that disseminated evidence-based exercises for mental health,” Chacko said. “So we decided to build something that gets to know you better, using your heart rate and your data, and then suggests when to do a helpful exercise to alleviate stress.”

The team learned this month that Mindset is a finalist in the App Idea Awards, a national competition in which the winner receives $70,000 in app development and design.

The team, originally made up of six students, formed as part of IDEA Labs, a student-driven bioengineering design and entrepreneurship incubator that works in partnership with the Schools of Medicine and of Engineering & Applied Science and the Skandalaris Center for Interdisciplinary Innovation and Entrepreneurship.

Written by Tamara Bhandari

Engineers put ethical thinking into action

Above: Engineering students tour EarthDance Farms in Ferguson, Mo. Right: Sandra Matteucci

Why did the Challenger shuttle explode?

The short answer: the faulty design of its O-rings. But the real culprit, experts found, was a NASA culture that sacrificed safety for expediency.

For years Sandra Matteucci, lecturer and director of the Engineering Communication Center, has explored the Challenger in her ethics class, “Engineering Ethics and Sustainability.” The disaster is a profound example of the life-and-death decisions engineers are called on to make. This semester, however, she set the course in a city that has suffered its own tragedy: Ferguson.

“The problems at NASA existed long before the Challenger disaster, just as the issues in Ferguson existed before the protests,” Matteucci says. “This class explored the parallels. What happens when systemic problems are ignored?”

Titled “Destination Ferguson: Looking at Urban Sustainability Challenges Through the Lens of Engineering Ethics, Leadership and Conflict Management,” the class of 20 engineering students met daily in Ferguson during spring break. They spent a day at the Challenger Learning Center in Ferguson, ate in Ferguson restaurants, visited Ferguson businesses and attended class in the Ferguson Community Center, where the Ferguson City Council recently approved a federal plan to improve its police and courts.

But they also explored engineering case studies, such as the Love Canal Superfund site and the Bridgeton Landfill fire, where technical decisions were made without consideration of the broader community.

By the end of the week, Thomas Brunoni saw the connections.

“Engineers solve problems; it’s what we do,” says Brunoni, a senior studying chemical engineering. “We learn how systems work and how the variables interact. For me, that’s understanding the relationship between molecules. But in communities, the relationships are between people and institutions. And here, the system failed.”

Matteucci tells her students many of the hardest decisions they make on the job will be ethical, not technical.

“We all assume, ‘We’re good people, we’ll do the right thing,’” Matteucci says.

“But that’s before you see the shades of gray and competing interests. You need to know how to put your ethical thinking into action. You’re going to encounter people, whether it’s in the plant or City Hall, who say, ‘This is too expensive’ or ‘This is an acceptable risk.’ That’s why you also need leadership, negotiation and communication skills.”

Written by Diane Toroian Keaggy

From left: Frank Yin, Robert Langer and Grace Yin

BME Day 2016 featured IDEA Labs Demo Day, MIT’s Langer

Robert S. Langer, ScD, of the Massachusetts Institute of Technology, was the inaugural speaker for the Frank & Grace Yin Distinguished Lectureship in Biomedical Engineering held April 26.

In addition, graduate students and professors from WashU’s Department of Biomedical Engineering made presentations to celebrate the department’s impact on the understanding of living systems and the development of new technologies to diagnose and treat disease.

Williams to study airborne gases with NSF CAREER Award


BRENT WILLIAMS

When walking or driving in an urban area, you may catch smells of food cooking, but is the smell coming from food cooking at a restaurant or from a bus burning biodiesel fuel?

Brent Williams, the Raymond R. Tucker Distinguished I-CARES Career Development Assistant Professor, will use a five-year, $500,000 CAREER Award from the National Science Foundation to develop ways to track particles and gases in the air back to their original sources. His project is titled "Laboratory Studies on the Chemical Characterization of Atmospheric Emission Sources and their Oxidative Evolution using Novel Instrumentation."

"Brent Williams is an integral member of the Center for Aerosol Science and Engineering (CASE) — a group of seven faculty who work with about 35 PhD students and other researchers," said Pratim Biswas, the Lucy and Stanley Lopata Professor and chair of the Department of Energy, Environmental & Chemical Engineering. "Brent is not only an active researcher, but he has played a leading role in coordinating the efforts of the group. His work on unraveling the organic constituents of aerosols is noteworthy, and some of the instruments he has developed are widely used by researchers across the world to better understand particle formation and impacts on climate change. I have particularly benefited in my collaborative work with him, where we have unraveled the organic constituents of combustion emissions."

Survival of the hardest working: Cells that work hard stay alive; lazy cells die

A team of engineers discovered a way to improve production of biofuels, pharmaceuticals, materials and other useful chemicals by capitalizing on the work ethic of cells.

Engineered strains of *E. coli* were used in the cellular kill switch research. The PopQC sensor rewarded high-performing bacteria with extra protein to grow and thrive; the lazy bacteria were eliminated.

The research team, led by Fuzhong Zhang, assistant professor of energy, environmental & chemical engineering, discovered that genetically identical microbial cells have different work ethics. The team developed a tool to ensure that the hard-working cells keep working hard and the low-performing cells are eliminated. The research was published online in *Nature Chemical Biology* March 21.

Zhang also was selected to receive the 2016 Daniel I.C. Wang Award from the journal *Biotechnology & Bioengineering*.

The award, named for Daniel I.C. Wang, an Institute professor at the Massachusetts Institute of Technology (MIT) and a pivotal leader in developing the biotechnology industry, honors an accomplished younger member of the biotechnology and bioengineering community for his or her commitment to the journal and to the community it serves.

The award recognizes Zhang's contribution in engineering the bacterial fatty acid biosynthetic pathway to produce "non-natural" chemicals that can be used as advanced biofuels with significantly improved combustion properties than conventional biofuels.

Furukawa teams with Zillow to create smartphone room mapping app

When shopping for a house, buyers may want to see what rooms look like beyond two-dimensional photos before scheduling a visit. A computer scientist from Washington University in St. Louis is working to make that happen in partnership with Zillow Inc.

Yasutaka Furukawa, assistant professor of computer science & engineering in the School of Engineering & Applied Science, has received a one-year, $68,081 grant from Zillow to study computational algorithms to build a 3-D model room outline using a smartphone. In particular, he will study how to acquire effective input images and videos for the task and how to reconstruct a room outline from such input.

Lu named IEEE Fellow


CHENYANG LU

Chenyang Lu, the Fullgraf Professor, has been named an IEEE Fellow. Lu is recognized for his contributions to adaptive real-time computing systems. The IEEE Grade of Fellow is conferred by the IEEE Board of Directors upon a person with an outstanding record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year cannot exceed one-tenth of 1 percent of the total voting membership. IEEE Fellow is the highest grade of membership and is recognized by the technical community as a prestigious honor and an important career achievement.

Real-time systems are an important class of computing systems with stringent real-time performance requirements such as those controlling automobiles and industrial automation. As real-time systems become increasingly open and interconnected in unpredictable environments, they must maintain real-time performance when system workload changes dynamically. Traditional approaches of real-time computing cannot handle unpredictable environments effectively because they rely on *a priori* knowledge of the workload to provide real-time performance assurance.

Lu pioneered a new approach to design adaptive real-time systems based on dynamic system models and feedback control techniques. He developed open-source middleware systems that provide real-time performance control services for different applications. His work played a crucial role in transforming ad hoc designs of adaptive real-time systems to a sound engineering methodology and system architecture.

Calcium carbonate: A new weapon in fighting tumors

Engineers have found a way to keep a cancerous tumor from growing by using nanoparticles of the main ingredient in common antacid tablets.

The research team, led by Avik Som, an MD/PhD student, and Samuel Achilefu, the Michel M. Ter-Pogossian Professor in Radiology and professor of biochemistry & molecular biophysics in the School of Medicine and of biomedical engineering in the School of Engineering & Applied Science, in collaboration with two labs in the School of Engineering & Applied Science, used two novel methods to create nanoparticles from calcium carbonate that were injected intravenously into a mouse model to treat solid tumors. The compound changed the pH of the tumor environment, from acidic to more alkaline and kept the cancer from growing.

With this work, researchers showed for the first time that they can modulate pH in solid tumors using intentionally designed nanoparticles. Results of the research were recently published online in *Nanoscale*.

"Cancer kills because of metastasis," said Som, who is working on a doctorate in biomedical engineering in addition to a medical degree. "The pH of a tumor has been heavily correlated with metastasis. For a cancer cell to get out of the extracellular matrix, or the cells around it, one of the methods it uses is a decreased pH."

Three biomedical engineering professors elected as AIMBE Fellows


JIANMIN CUI


DANIEL MORAN


ROHIT PAPPU

Three professors from the School of Engineering & Applied Science have been elected to the 2016 College of Fellows of the American Institute for Medical and Biological Engineering, representing the top 2 percent of medical and biological engineers in the country.

Jianmin Cui, Daniel Moran and Rohit Pappu, all professors in the Department of Biomedical Engineering, were inducted as fellows April 4 in Washington, D.C.

AIMBE's College of Fellows is composed of about 1,500 individuals who have made significant contributions to the medical and biological engineering community in academia, industry, government and education that have transformed the world. Fellows are nominated each year by their peers and work toward realizing AIMBE's vision to provide medical and biological engineering innovation for the benefit of humanity.

"We are proud of Jianmin, Dan and Rohit, who have devoted their careers to research and innovation that will ultimately improve the quality of life for many people," said Steven C. George, MD, the Elvera & William Stuckenberg Professor of Technology & Human Affairs and chair of the Department of Biomedical Engineering. "They are not only world-class leaders in their fields, but also outstanding mentors and role models for our students."

Artificial antibodies present new possibilities

SRIKANTH SINGAMANENI

Srikanth Singamaneni, associate professor of materials science, is working to speed up medical diagnostics. Using artificial bioreceptors and metal nanostructures, Singamaneni, in collaboration with Evan Kharasch, MD, and Jerry Morrissey, has set the groundwork to create durable, point-of-care (POC) diagnostics for heart attack and kidney injury.

The plasmonic sensors based on an artificial antibody platform could be easily implemented using a miniature battery-operated spectrometer to potentially enable testing in POC settings, such as ambulances and urgent-care facilities. For example, the platform would allow accurate testing for a heart attack in the ambulance, providing critical test results much sooner than currently possible.

"One of the biggest advantages of this technology is the ability to rapidly develop biorecognition elements for any protein biomarker," Singamaneni said. "The conventional method forces us to use natural antibodies, which take much longer to develop. Our artificial antibodies can be adapted to various proteins, creating a platform that can be used in a wide range of diagnostics. Moreover, these artificial antibodies are remarkably stable compared to their natural counterparts."

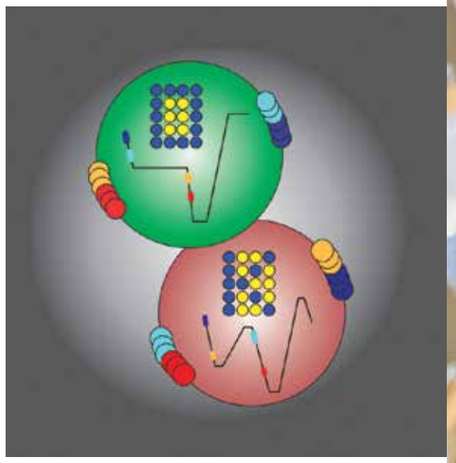
Written by Office of Technology Management

Study sheds light on patterns behind brain, heart systems, circadian rhythms

A systems engineer has designed a method that, figuratively, forces a leopard to change its spots.

Jr-Shin Li, the Das Family Distinguished Career Development Associate Professor in Electrical & Systems Engineering, has devised a unified mathematical framework to design a single global input, or waveform, that is able to inspire a population of nonlinear rhythmic units ubiquitous in nature and man-made systems. The theory has been shown on a nickel multielectrode array (the leopard) to form first one pattern, the letter O, then a short while later switches to another pattern, the letter K, and then returns to the initial pattern O again. Each pixel in the letter is a chemical reaction.

The significance of the study is the contribution to advance the ensemble control theory with the development of effective computational algorithms



that will enable researchers to better understand and control oscillation in a variety of important application domains, such as heart pacemakers, neuronal firings in the brain and circadian timekeeping. Getting the 20 oscillatory reactions on an array to switch patterns is an example of "entraining" abundant, often similar dynamical systems simultaneously by a single command or input.

Trap and neutralize: A new way to clean contaminated groundwater

A team of researchers has helped discover a new chemical method to immobilize uranium in contaminated groundwater, which could lead to more precise and successful water remediation efforts at former nuclear sites.

Researchers in the lab of Daniel Giammar, the Walter E. Browne Professor of Environmental Engineering, ran a series of experiments in a laboratory setting using water containing uranium — present in contaminated groundwater at various sites in the United States as a legacy of Cold War-era processing and waste disposal activities associated with nuclear materials production.

Calcium and phosphate work together chemically to immobilize uranium, which is shown to lead to increased cancer risk and liver damage in humans when ingested. Past field studies, including one at the Hanford Site in the state of Washington, focused on an in situ solution that injected phosphates directly into contaminated groundwater. Remediation efforts were not fully successful, because the scale of overlap for the calcium, uranium and phosphates was limited.

Written by Erika Ebsworth-Goold

WUSTL PHOTO

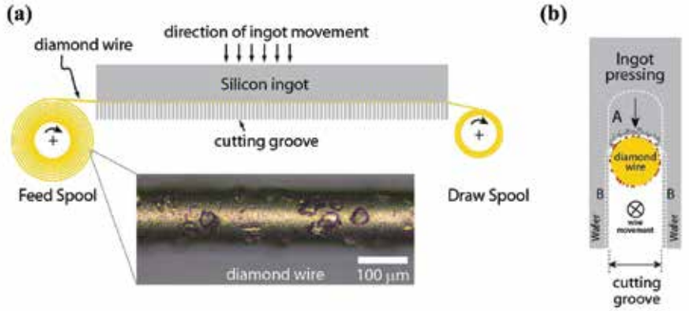
Setton lab awarded $1.2M NIH grant

Aided by a $1.2 million grant from the National Institutes of Health, a team from WashU will continue its work studying the nucleus pulposus cells that comprise human intervertebral discs in an effort to keep them healthy and functional. The research has potential to lead to intervertebral disc regeneration.

Lori Setton (left), the Lucy and Stanley Lopata Distinguished Professor of Biomedical Engineering , will try to prolong survival of the nuclear pulposus cells with the help of designer biomaterials. Working with Don Elbert (center), associate professor of biomedical engineering, Setton's lab will develop protein-hydrogel hybrids that mimic a healthy intervertebral disc environment to promote increased pulposus cell survival and biosynthesis for self-repair.

Setton's lab also will examine certain proteins that play a role in intervertebral disc health. Her prior work identifies the presence of some proteins in discs of younger people that seem to disappear with aging and pathology, including specific types of laminin. Setton and Elbert will work to identify ways to incorporate these laminin proteins into model hydrogel systems to construct artificial tissue mimics, creating cellular environments to support the health of intervertebral disc cells.

Could carbon be silicon's best friend?



Parag Banerjee, assistant professor of materials science, has received a three-year, $300,000 Grant Opportunity for Academic Liaison with Industry (GOALI) from the National Science Foundation to work with SunEdison Inc., a Maryland Heights, Mo.-based renewable energy development company, to find a more efficient way to cut silicon into wafers using carbon fiber and diamonds.

SunEdison, one of the largest manufacturers of silicon wafers worldwide, uses the wafers in solar panels. Silicon wafers are cut from silicon ingots, which are about 15 centimeters by 15 centimeters square. Cutting the ingots into wafers comprises about 11 percent of the final cost of solar energy panels. Reducing waste and cost to cut the wafers could ultimately reduce the cost of solar energy panels.

With the funding, Banerjee and his lab will test cutting silicon ingots with carbon fiber wires that are 75 microns in diameter to see if the thinner, carbon fiber wires can stand up to the force needed to slice the wafers.

Nanoparticles present sustainable way to grow food crops

Ramesh Raliya, a research scientist, and Pratim Biswas, the Lucy & Stanley Lopata Professor and chair of the Department of Energy, Environmental & Chemical Engineering, discovered a way to reduce the use of fertilizer made from rock phosphorus and still see improvements in the growth of food crops by using zinc oxide nanoparticles.

The research was published April 7 in the *Journal of Agricultural and Food Chemistry*. Raliya says this is the first study to show how to mobilize native phosphorus in the soil using zinc oxide nanoparticles over the life cycle of the plant, from seed to harvest.

EVERYTHING'S CONNECTED

Written by **BETH MILLER**

Illustration by **STEVE EDWARDS**

In the past five years, smartphones and wearable fitness- and health-tracking devices have become must-haves rather than luxuries. And the number of connected devices we use increases daily, including vehicles, smart thermostats, medical devices, kids' toys.

These consumer-focused connected devices are only a fraction of the Internet of Things (IoT), or the network connectivity between objects that allows them to perform their jobs. Commerce and industry have steadily increased their use of applications using the Internet of Things, including for industrial automation and processes, remote monitoring, health care, manufacturing, agriculture and transportation.

This trend is only expected to get bigger. John Chambers, former CEO and executive chairman of Cisco Systems Inc., predicted recently that 500 billion devices would be connected to the Internet by 2025, while others estimate 20 billion to 35 billion. Either way, more and more devices will comprise the Internet of Things in the next decade, including autonomous cars, mattresses that measure heart rate and other vital signs to promote better sleep, soil-moisture detectors to increase crop yield, water-use tracking apps and even an app to track if elderly people living alone are taking their medications on time. Ford Motor Co. recently announced plans for an app called FordPass that would suggest better traffic routes to Ford drivers, connect with the drivers' home to turn on the heat or air conditioning and open the garage door minutes before they arrive.

This year, more than 6.4 billion connected devices are expected to be in use worldwide, with 5.5 million new things getting connected every day, according to information technology research firm Gartner Inc. More than 21 percent of total Internet of Things use is expected to be in smart homes. In early 2014, Google paid $3.2 billion to buy Nest, a smart thermostat that uses sensors to train itself on the user's patterns. In late 2014, Amazon entered the space with the Echo, a wireless, cloud-based, voice-operated device that plays music, answers questions, gives news and weather, controls lights, thermostats and other smart-home devices, and recently introduced a smaller, less expensive version called Echo Dot.

The IoT's impact on the economy is expected to be between $3.9 trillion to $11.1 trillion per year in 2025 in nine different sectors, including vehicles, home, offices, factories, retail, worksites, human, outside and cities, with huge, untapped potential in developing countries, according to a June 2015 report by McKinsey & Co.

While the Internet of Things may make life easier by allowing more connections, it presents technical, security and privacy challenges, which faculty and graduate students in the School of Engineering & Applied Science are addressing from different angles, from developing new health-care applications to managing privacy and security concerns.

2016

6.4 billion
CONNECTED DEVICES ARE EXPECTED TO BE IN USE WORLDWIDE

5.5 million
NEW THINGS GETTING CONNECTED EVERY DAY

24 hours

2025

500 billion
DEVICES WOULD BE CONNECTED TO THE INTERNET

WASHU ENGINEERING MAKES THE CONNECTIONS

Health care

Yixin Chen and Chenyang Lu, both professors in the Department of Computer Science & Engineering, are part of an interdisciplinary team to improve health-care outcomes for the sickest patients using the Internet of Things. Since 2008, they have worked with Thomas Bailey, MD, and Marin Kollef, MD, both professors of medicine at Washington University School of Medicine, to develop an early-warning system that would alert medical staff that a patient was in peril of needing care in the intensive care unit (ICU) or was near death.

In one of the team's projects, they mined traditional clinical data of 34 vital signs from historical electronic medical records of 50,000 Barnes-Jewish Hospital patients. Their algorithms analyze the data, which has had all identifying information removed, looking for patterns that provide an early warning of any signs that the patient was deteriorating or may have a life-threatening event.

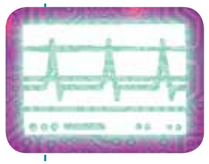
For example, a patient may have a normal heart rate but a body temperature with a pattern that matches that of previous patients who went into septic shock. The early-warning system would recognize that pattern from the historical data of previous patients and send a text to the patient's nursing team, who can take immediate action.

"Those who received an alert were eight times more likely to be transferred to the ICU and 10 times more likely to die than those who did not receive an alert," Chen said. "The alert is a very strong indicator of sudden deterioration and death."

Lu, with Chen, Bailey and Kollef, developed and piloted one of the world's first large-scale clinical monitoring systems that collected real-time vital signs from patients using wireless sensors. The wireless monitoring system was tested in a 14-month clinical trial in six wards of Barnes-Jewish Hospital.

While the work showed that vital signs from patients could be taken reliably through the wireless sensor network integrated with hospital IT infrastructure, there were some roadblocks, said Lu, the Fullgraf Professor, such as the convenience of the wireless sensors today. Fortunately, wearable medical sensors are rapidly improving in both form factor and functionality, which bodes well for future adoption of the wireless clinical monitoring technology.

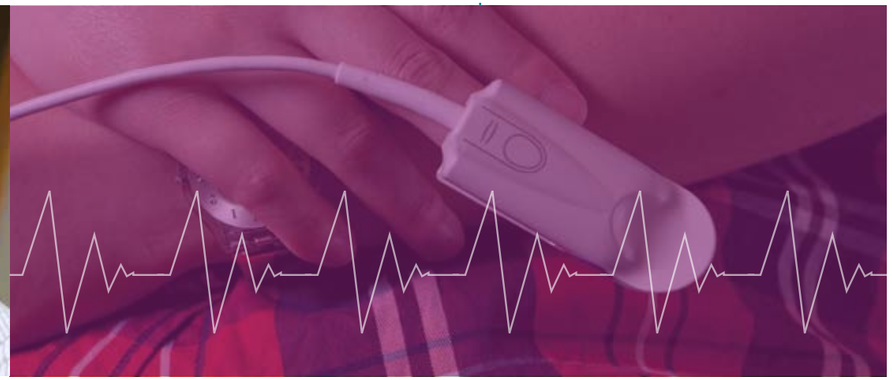
Now, the team is preparing a new trial with Lu's wireless sensor software, except this time, they plan to use Fitbit wearable tracking devices to gather data from patients after they are discharged from the hospital. That data will be monitored and compared to historical data to look for indications that the patient may need to be readmitted.



clinical data

34

VITAL SIGNS WERE ANALYZED FROM THE MEDICAL RECORDS OF 50,000 PATIENTS



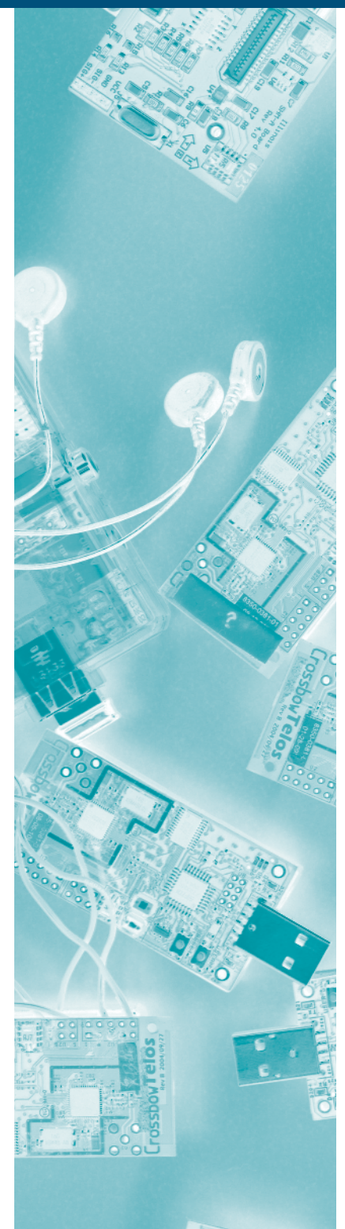
> Using the Internet of Things has to save costs — there has to be bang for the buck. Traditional industries are not talking about creating new sectors, but making traditional existing economics more efficient through instrumentation of the process using the Internet of Things as a tool. — CHENYANG LU

Infrastructure and industry

In addition to health care, Lu was part of a multi-university team in 2013 that developed wireless systems that could be used to detect structural damage in bridges and buildings and control them in the face of disasters such as earthquakes. The wireless cyber-physical simulator they built shed light on the challenges and limitations of both wireless and traditional structural controls, as well as potential new designs for a wireless control system using sensors installed on the infrastructure.

Wireless systems allow companies to monitor their machines and engines via the Internet to ensure they are always performing properly, Lu says. Companies with industrial automation, manufacturing, process control and oil refining processes face the challenge of having equipment in remote areas where it is difficult and expensive to lay wires. A wireless monitoring and control system using the Internet of Things could be a big cost-saver, Lu says.

"Using the Internet of Things has to save costs — there has to be bang for the buck," he says. "Traditional industries are not talking about creating new sectors, but making traditional existing economics more efficient through instrumentation of the process using the Internet of Things as a tool. All of these traditional sectors are a potential marketplace for the Internet of Things, and that's why people do the math and say this is why it will be so huge."



Security and privacy

As companies use more and more connected devices and machines, it becomes more difficult to secure them. While security software is available for computers, it is not yet available for smart thermostats, webcams or industrial automation systems. Voice-activated devices may be able to pick up private conversations that could be accessed by others.

"Every form of electronics wants to connect to the network to do its job," says Patrick Crowley, professor of computer science and an expert in network security. "From the perspective of an organization, whether it is a power plant or a business or a data center, the number of connected things is going up, and the ability of the IT staff to manage them by installing software and other means is going down. These are substantive challenges that make it hard for individuals and organizations to feel confident that they've really secured their information resources."

Crowley says there are two ways to address these challenges. One is to stop using them because of the risks involved, but that is not a practical solution.

"As a thought experiment, consider your own laptop and all the ways it helps you get things done," he says. "Now imagine that you can no longer connect it to a network. How much of that value remains? Devices become very useful once they are connected."

The second option, developing new approaches and methods for securely

> From the perspective of an organization, whether it is a power plant or a business or a data center, the number of connected things is going up, and the ability of the IT staff to manage them by installing software and other means is going down. — PATRICK CROWLEY

connecting devices, is one very familiar to him. In 2011, Crowley founded Observable Networks, which developed proprietary technology to secure these networks. The company provides endpoint modeling and automated security analytics to companies in industries that need to secure their networks.

Crowley also is a major player in a new secure technology to connect digital devices known as Named Data Networking (NDN). He is principal investigator on a National Science Foundation (NSF)-funded project and heads WashU's participation in the nationwide NDN consortium.

Currently, the Internet is based on an address — every device must be able to establish a telephone call with any other device through that address. With the number of connected devices increasing daily, that system becomes unsustainable, Crowley says. In addition, the Internet uses an honor system: there is no foundation of authentication and trust in Internet protocols.

That's where NDN comes in, he says. NDN retains many of the virtues in current Internet protocols, yet addresses the shortcomings presented by the Internet of Things' cloud-based networking. It does not require that every device know the address of any other device. Instead, it requests named data, meaning that every connected device asks for the data it is looking for, and the network must determine how to supply the data.

"The way we communicate on the Internet today is dramatically more efficient and secure with NDN than it is with the Internet protocols," Crowley says. "Every packet of data in an NDN network is cryptographically signed by the entity that produced it, so when one device makes a request of another device and receives that data, that device has the ability to verify whether that signature is correct. It's a fundamentally different foundation for trust and security."

Raj Jain, the Barbara J. and Jerome R. Cox Jr. Professor in Computer Science, says security and privacy are the most important challenges in the IoT, and his group is approaching it from a different angle.

"Eighty percent of devices have no privacy, and 70 percent of devices don't use encryption," he says. "When you're using an IoT device, if your phone, the WiFi network, the cloud, the cellular network, or the user's password is compromised, the security can be breached. There are nine links in the IoT chain, and if any one of them is unprotected, strong protection in others doesn't matter."

Jain and his group are studying the security weakness in the IoT. In particular, improper life-cycle management, such as installing the device with default options, updating the firmware without proper signature checks or recycling a used device without resetting may compromise security.

"For example, when you get a notification on your computer to update a program or utility, such as Java, if you let it update without verifying that the message is from a legitimate program, you can easily compromise your computer," he says. "Everything requires two-way authentication to ensure that the server and client are both legit. In many IoT applications, client is the only one that is authenticated, leaving security holes for attackers using fake servers."

Smart homes

Making homes more energy efficient has been a goal for nearly 40 years, but WashU engineering and architecture students now have the opportunity to build a true smart home through the university's first Solar Decathlon team. The U.S. Department of Energy sponsors a Solar Decathlon every two years and selects collegiate teams to submit an entirely solar-powered home in an international competition. Several of the 10 contests — architecture, market appeal, engineering, communications, affordability, comfort zone, appliances, home life, community and energy balance — involve the Internet of Things.

Hongxi Yin, I-CARES Associate Professor, and Pablo Moyano Fernández, senior lecturer, both in the Sam Fox School of Design & Visual Arts, are two of the faculty members leading the WashU Solar Decathlon team, which includes undergraduate and graduate students from the Sam Fox and Engineering schools. The team will work on the project for two years before participating in the competition in the fall of 2017.

In the competition, each team has to build a home and demonstrate how it would work over a 24-hour period, including supplying energy to appliances; heating, ventilating and air conditioning systems (HVAC); computers; televisions and to charge an electric car to drive 25 miles every day.

"We need to make sure the house uses the least amount of energy possible and is still comfortable to use," Moyano Fernández says. "The students have spent a lot of time researching sustainable strategies in general, then those in the building industry, and are learning what strategies to apply when building a house to make it more sustainable while lowering the operational cost."

The students are working in five focused groups. Lu's wireless sensor technology will be integrated into the house based on the work of students in his Wireless Sensor Networks course (CSE 521S).

"We are integrating architecture, health care, landscape architecture, art, structure, solar, mechanical engineering, electrical engineering, materials and construction management," Yin says. "The Solar Decathlon is a great platform to integrate research and education in a real-life situation."

In the lab of Humberto Gonzalez, assistant professor of electrical & systems engineering, doctoral student Runxin He is writing control algorithms for the HVAC systems in a university-owned apartment building at 749 Westgate Ave. that is being renovated as part of the university's Green Rehab project.

"Our idea is that if we can find some smart algorithms or strategies for buildings, the country's energy costs for buildings can decrease to just one-third of current usage," He said.

He's algorithm allows the apartment's HVAC system to recognize the location of each resident in the apartment and change the climate in that area for the resident's comfort, then shut off the HVAC in the rest of the apartment to save energy. In the future, this could be done through a smartphone app or wearable device, He said.

10 elements

- ARCHITECTURE
- MARKET APPEAL
- ENGINEERING
- COMMUNICATIONS
- AFFORDABILITY
- COMFORT ZONE
- APPLIANCES
- HOME LIFE
- COMMUNITY
- ENERGY BALANCE

SOLAR DECATHLON

WHAT LIES AHEAD

Students also will be getting involved in the Internet of Things through the ArchHacks hackathon hosted at WashU Nov. 4-6. More than 500 college students will gather for 48 hours to collaborate, solve problems and create solutions for the HealthTech theme. Sponsors include big names in the health tech industry, including ExpressScripts, Centene Corp. and Pfizer Inc., as well as Misfit and Google. Sixteen WashU undergraduate students are coordinating the hackathon.

Alumnus and Engineering National Council member Gaurav Garg, founding partner of Wing, a venture capital firm in Silicon Valley, was early to invest in the Internet of Things. In 2004, he began working with Jahangir Mohammed, who founded Jasper, a company that allows companies to turn their Internet of Things products into successful services businesses. On Feb. 3, 2016, Cisco acquired Jasper for $1.4 billion.

In a blog post, Garg, who has been a member of Jasper's board for 11 years, wrote that the acquisition "marks a significant milestone in the Internet of Things." As of that day, more than 3,500 companies ran Internet of Things services through Jasper's platform.

"I would say the Internet of Things is the most important thing going on in the world right now," says Garg, who earned bachelor's degrees in electrical engineering and computer science in 1988 and a master's in electrical engineering in 1990.

"The physical world will be transformed by being connected," he says. "We'll have intelligence on what's going on in the real world all the time."

> Our vision of the future is very constrained by what we have now. But for the next 30 years or more, we're going to see many apps for physical objects appear that we can't even imagine today. — GAURAV GARG

Caitlin Kelleher

Empowering others to learn

Written by **BETH MILLER**

Computer skills have been taught in schools since the 1980s, but programming is not generally integrated into the K-12 curriculum due to lack of funding, resources or trained teachers.

Caitlin Kelleher, the Hugo F. & Ina Champ Urbauer Career Development Associate Professor in the Department of Computer Science & Engineering, focuses on how programming environments can support kids ages 10-17 to most effectively learn computer programming — not necessarily to pursue programming as a career, but to develop problem-solving skills, express creativity and understand its relevance to nearly everything.

Kelleher first began her focus on computer programming nearly 15 years ago as a doctoral student at Carnegie Mellon University under the mentorship of the late Randy Pausch, an expert in human-computer interaction and author of "The Last Lecture." Since then, the topic has become a national priority, with President Barack Obama launching the Computer Science for All Initiative Jan. 30, which will pump $4 million in funding to states to allow them and school districts to expand Science, Technology, Engineering and Mathematics (STEM) offerings to ensure all students have the chance to participate, including girls and students from backgrounds underrepresented in STEM fields.

That is a top priority of Kelleher's, as well.

"In thinking about how to get a more diverse sampling of people into computer science, the kinds of technologies we create are a natural reflection of our own life experience," she says.

RON KLEIN

> "When you have a population of people in computing that doesn't represent the country or world as a whole, you're not going to see all of the technologies that could exist. It's in the best interest of the world's perspective to have increased diversity in computing."
>
> — CAITLIN KELLEHER

Michelle Ichinco and Kyle Harms are both PhD students in Kelleher's lab.

"When you have a population of people in computing that doesn't represent the country or world as a whole, you're not going to see all of the technologies that could exist. It's in the best interest of the world's perspective to have increased diversity in computing," Kelleher says.

In his Jan. 30 weekly address, Obama called for all students across the country to learn computer science in school, saying it is a "new basic" skill necessary for economic opportunity.

"Now we have to make sure all our kids are equipped for the jobs of the future — which means not just being able to work with computers, but developing the analytical and coding skills to power our innovation economy," Obama said. "And workers of all kinds need to be able to figure out how to break a big problem into smaller pieces and identify the right steps to solve it."

And that is exactly what Kelleher is working to achieve through Looking Glass (lookingglass.wustl.edu), a graphics-based system she designed to support kids in middle and high school as they learn to program on their own.

"I've always been drawn to education as a problem space because it seems like it is one of the things that you can give people that can really have a dramatic impact on their lives," Kelleher says.

Looking Glass is based on a programming environment that Kelleher created at Carnegie Mellon called Storytelling Alice, initially designed to teach college students how to program. When she came to the School of Engineering & Applied Science at Washington University in 2007, she launched Looking Glass, a one-of-a-kind platform that allows users to learn to program by creating their own personalized animated stories with fun characters, such as aliens, trolls or animals, that can be programmed to perform different actions, like doing a backflip or spinning on a sheet of ice, or having a conversation with each other. These custom stories, called worlds, use simple drag-and-drop actions to create the activity or conversation in the world, which can be played back at any time. In addition, users can share snippets of their actions with other users and remix a variety of actions into their own stories.

Using Looking Glass, Kelleher and her team are studying how programming environments can support kids learning to program on their own through several avenues: playing and exploring, through puzzles to support different needs and styles of independent learners, and outreach and mentoring with professional programmers.

The play-and-explore aspect allows users to see a function in a story that captures their attention and ask how it works; for example, "I want to know what happens when the UFO light beam appears." That creates an opportunity for the students to learn the steps needed to get the desired result.

For the puzzles, the team provides users with the final animation and the pieces needed to build it, then helps them determine how to put the pieces together to re-create the animation.

"The puzzles try to build a framework for learning how to use a variety of programming constructs by considering models of human learning in the design of the system, such that kids can focus purely on how different programming elements combine to achieve different goals," she says.

Now, with funding from the National Science Foundation, Kelleher and the team are expanding on that work by predicting how well a user will do on a new puzzle based on his or her past history.

"We're growing that work in a way that's inspired by cognitive load theory, which argues that learning is limited by short-term memory capacity, so we have to be careful about how many things we're asking someone to do simultaneously," she says. "We're looking at what kinds of patterns someone uses to solve the puzzle, and what does that say about the degree to which they understand the concepts within the puzzle, or the degree to which they are still building knowledge, or that they've exhausted other options and happened to stumble on the correct solution."

Kelleher and her team are also looking at a way to connect the knowledge of professional programmers with kids in the community who don't have access to programming education through mentoring. The mentors look through the code and make suggestions to users, as well as write rules that run static code analysis over all of the worlds that users have created to identify other programs that would benefit from the same idea.

"Rather than just having that person have influence over one world that they worked on and one kid who authored that world, the idea gets broadcast to a much wider audience of people," she says.

Kelleher says computer programming is relevant to every field, which is why it is important for everyone to learn it.

"You can take on whatever problem you think is most compelling in the world and think about ways computing and technology can help address that," she says.

1998

Kelleher earns a BS in computer science at Virginia Polytechnic & State University (Virginia Tech)

2006

Kelleher earns a doctorate from Carnegie Mellon University

2007

Kelleher joins the Engineering faculty at Washington University

2011

Kelleher receives a National Science Foundation CAREER Award

2013

Kelleher receives the Sloan Research Fellowship

2014

Kelleher receives Innovation Award from the Academy of Science – St. Louis

Out into the world

A degree in Engineering from Washington University in St. Louis opens doors to careers ranging from hands-on engineering to research to teaching to medicine. After spending the past few years learning in a community of innovative thinkers, these 2015 and 2016 graduates of WashU Engineering discuss how their education prepared them for a career, what the job search was like and what careers path they have chosen, and they share advice for future job seekers.

Photos by **WHITNEY CURTIS**

Kelsey Lipman

BS, Biomedical Engineering

Columbia University College of Physicians and Surgeons, New York City

Why medical school?

As a sophomore, I became involved with Engineers Without Borders here on campus. I traveled to Guatemala City with a team of engineers to repair medical equipment and analyze the logistics of the hospital. On this trip, I realized that I wanted to experience health care from another perspective. I wanted to gain exposure to patient-physician interactions and understand the daily responsibilities of being a physician. Returning to WashU, I joined a medical brigade to gain clinical exposure and experience global health from a clinical, rather than engineering, standpoint. The medical brigade solidified my interest in medicine and global health, and I led the trip the following year.

Ben Lake

BS, Mechanical Engineering; minor in mathematics; also working toward a master's in materials science

Job: Mechanical design engineer, Spartan Light Metal Products, Sparta, Ill.

Why did you want the job?

I wanted to work for Spartan Light Metal Products because of the people and the opportunities to use my mind to solve problems. It is important to me to be able to use my problem-solving skills to understand and work through situations.

What advice would you give to students?

The best advice that I can give a person on finding a job is to be proactive, get to know people and, most importantly, make friends. There is no comparison to a face-to-face interaction and a hand shake.

Wenlin Chen

PhD, Computer Science

Job: Research scientist, Facebook, Menlo Park, Calif.

Why did you want the job?

I am very interested in artificial intelligence (AI), and I deeply believe AI would make the world a better place to live. Why did I choose to do AI at Facebook? First, when I was doing an internship at Facebook, I was quite fascinated by its open culture. Second, I love the mission of Facebook to give people the power to share and make the world more open and connected. And I believe AI will play an important role toward this goal. Last, but not least, Facebook has rich data, nice infrastructure and top talent, which are very important for successful research and engineering.

Christian Lukas

BS, Computer Science and Mathematics

Job: Software Developer, Epic, Madison, Wis.

How did WashU prepare you?

I wasn't made aware I'd be conducting a case study before the interview and didn't do any preparation. In spite of going in relatively blind to the process, I was able to draw on some of the problem-solving skills emphasized in a variety of my classes (advanced algorithms 441T and machine learning 417A, especially). My education helped me do very well on that part of the interview.

Tong Niu

MS, Information Systems, Sever Institute, Professional Education

Job: Big Data and Cloud Support, Amazon, Seattle

How did WashU prepare you?

A WashU education helped me a lot for this new job. My program exposed me to a lot of Big Data, one of the hottest areas in IT and data science. Since I didn't have much computer science background before, WashU's computer science courses taught me a lot about programming and data analysis.

Jiaxi Fang & Tandeep Chadha

PhD, Energy, Environmental & Chemical Engineering

Job: Co-founders, Applied Particle Technology, St. Louis

Why did you decide to start a company?

There haven't been many significant advances in air purification technologies in the past several decades, while there is mounting evidence that air quality can have significant health consequences. Thus, there is a need for new air filtration technologies. This is an exciting opportunity to solve real-world problems with air quality and air pollution by developing innovative approaches to air purification.

Natasha Tillett

BS, Biomedical Engineering; Electrical Engineering minor

Job: Secondary Chemistry teacher, Teach For America, Mississippi

Why did you want the job?

I've always found myself in tutoring or mentoring roles, and I've been told all my life that I'm good at explaining things to people, so teaching seemed to fit. I'm also very passionate about systemic inequalities, specifically those in education and health, so the mission of Teach For America resonated with me. Lastly, I'm pre-med, so the fact that I could have this job doing something that I'm passionate about while making an impact in the black community, and also having the flexibility to apply to medical school in a few years was the icing on the cake for me.

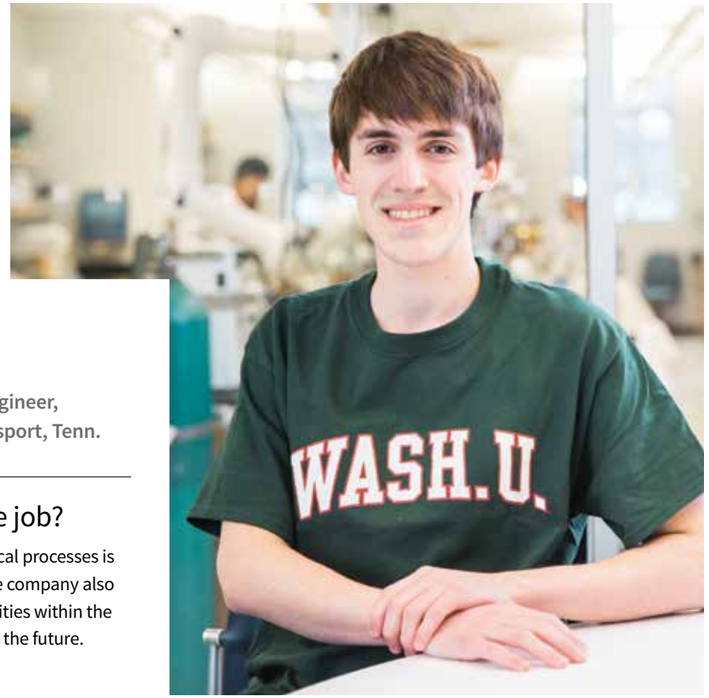
How did WashU prepare you?

WashU Engineering has helped me develop my ability to find creative and efficient solutions to complex problems. I have built a solid foundation in mathematical techniques, modeling and computer programming, among other topics. I have learned how to apply engineering concepts to many different types of systems and have enjoyed the opportunities to work on multidisciplinary teams. Having the opportunity to be part of Nike's Consumer Digital Technology department is a perfect way to blend my passions for sports and technology.

Kaitlyn Crawley

BS, Systems Engineering; minors in computer science and finance

Job: Software Engineer, Nike Inc., Beaverton, Ore.



Nick Riem

BS, Chemical Engineering

Job: Entry-level chemical engineer, Eastman Chemical Co., Kingsport, Tenn.

Why did you want the job?

Designing and optimizing chemical processes is something that interests me. The company also provides various other opportunities within the industry that I hope to explore in the future.

RON VESELY

Rohun Palekar

PhD, Biomedical Engineering

Job: Postdoctoral fellow, Northwestern University Feinberg School of Medicine, Chicago

How did WashU prepare you?

My WashU Engineering education, which included course work, research and interactions with faculty through research collaborations or thesis advisory committees, provided a very strong learning environment, which allowed me to develop the necessary skills that qualified me for my current position. I credit my great faculty advisers and teachers, high-quality course work and the resources provided by WashU in preparing me for my career.

Kenna Middleton

BS/MS, Mechanical Engineering

Job: Mechanical Engineering Intern, Insitu, Hood River, Ore.

What advice would you give to students?

Getting contacts within the company you are looking at is really helpful. This is not only because the company recognizes that you are a person and not a résumé, but to gain a deeper understanding of the culture and if it is the best fit for you.

COURTESY PHOTO

Gary Wendlandt

A lifelong love of learning

Written by **CHRISTOPHER TRITTO**

Gary Wendlandt retired at the end of 2010 as vice chairman of the board and chief investment officer of New York Life Insurance Co., where he was overseeing more than $260 billion in investments.

Catch up with Gary Wendlandt these days, and chances are you'll find him sailing in the Gulf of Mexico, strolling the streets of Paris or even relishing a moment in the spotlight on a Broadway stage. Wendlandt can attest to the joys of retirement following a successful career. And he traces much of his good fortune back to his undergraduate days at Washington University.

Wendlandt retired at the end of 2010 as vice chairman of the board and chief investment officer of New York Life Insurance Co., where he was overseeing more than $260 billion in investments. Although his was not a traditional career for a graduate from the School of Engineering & Applied Science, Wendlandt attributes his preparedness and agility to the education and experience he received in St. Louis.

"Washington University is a place where so many people love what they do and love learning, and if you embrace that, you will be much more successful no matter what you do," he says.

Wendlandt's interest in math and science was sparked at an early age. By the time he graduated from public high school in his hometown of Milwaukee, he figured he would train to be an engineer. It was 1968, and the University of Wisconsin campus was a hot spot for civil disobedience and protests surrounding the Vietnam War. So Wendlandt explored alternatives not too far from home and chose Washington University, where his father had taken classes as a young Army engineer.

He started out as a chemical engineering major but quickly gravitated toward applied mathematics, fascinated by the study of probability, statistics and mathematical operations.

ALEX STAFFORD

"Every course I took was a revelation," Wendlandt says. "All of the professors I came in contact with were completely in love with what they did."

The late Gustav Mesmer, a former professor of applied mechanics, was one such example.

"He had such great enthusiasm for something most people would find extremely dull," Wendlandt says, "and he conveyed that love in such a way that helped solidify my lifelong interest in learning."

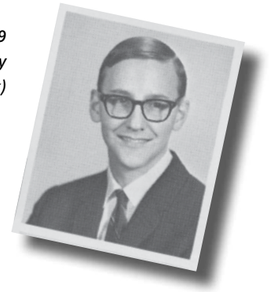
As Wendlandt approached graduation, his roommate's father, also a WashU alumnus, suggested Wendlandt go to work as an actuary at his company, Massachusetts Mutual Life Insurance Co. That led to Wendlandt's first job and set him on a career path in the insurance and financial industry.

> "I was taught to develop skills of discipline, organization and problem-solving that are important in any field."
>
> — GARY WENDLANDT

"Actuaries are the problem solvers, the engineers of insurance companies," Wendlandt says. "You get into things like underwriting and compensation, mortality, and interest theory — all the business that goes into making an insurance policy."

Wendlandt excelled, earned membership in the American Academy of Actuaries and the Society of Actuaries and assumed roles of increasing responsibility. In 1980, as the insurance industry scrambled to adapt to soaring interest rates, Wendlandt was tapped as the first actuary at MassMutual to join the firm's investment department to solve new problems. Three years later, he took charge as the company's head of securities investments, something unheard of for an actuary at the time.

"The investment side was as interesting as anything else I had done and maybe more," Wendlandt says. "You never come across the same problem twice. I learned how to solve problems in an organized, systematic fashion,



Gary (taken from a 1969 Washington University Hatchet yearbook)

while most people operated from emotions. That was in large part due to my training as an engineer. I was taught to develop skills of discipline, organization and problem-solving that are important in any field."

Over the next three decades, Wendlandt grew with MassMutual, eventually serving as chief investment officer before moving to New York Life Insurance Co., the largest mutual life insurance company in the U.S. and a Fortune 100 company, to create and lead that firm's investment activities through New York Life Investment Management LLC. He was credited by the company's chairman with steering the company's investment portfolio wisely through the 2007 and 2008 Great Recession. The "quality tilt" strategy that he used to adjust an investment portfolio to market conditions is now used as a case study in *Harvard Business Review*.

Wendlandt was elected to the university's Board of Trustees May 6, and in recognition of his professional achievements, WashU's School of Engineering & Applied Science bestowed its Alumni Achievement Award on Wendlandt in 2006.

Now retired, Wendlandt is taking time for fun away from the rigors of the corporate world. He splits his time between New York City and Marco Island, Fla., and takes several weeks a year to travel, sail, visit his five grandchildren, play the piano and attend the theater. Through charity auctions to support the Actors' Equity Association, Wendlandt once conducted the exit music for "The Phantom of the Opera" on Broadway. He took the stage in March as an extra in a performance of "Jersey Boys."

But he remains dedicated to service as well. Wendlandt is a long-standing member of the Boy Scouts of America's National Executive Board, where he has overseen its investment portfolio for more than 30 years. The organization gave him the Silver Buffalo Award, scouting's highest commendation for distinguished service to youth, in 2007.

COURTESY PHOTO

Gary Wendlandt, his wife, Peg, (front, center) and their family

Wendlandt also sits on the WashU Engineering school's National Council and shares his good fortune with future engineering graduates. He and his wife, Peg, have pledged an estate gift of more than $5 million in scholarships in what is the largest non-facility gift in the school's history. They also support one or two students each year through additional annual giving.

"My wife and I came from families that weren't that well-to-do, and we were given great opportunity despite that," Wendlandt says. "To help ensure that other people can enjoy a life of challenge and opportunity is very rewarding."

Wendlandt at "The Phantom of the Opera" performance on Broadway

Six alumni, former dean honored with 2016 Achievement Awards

Clockwise from top left: Provost Holden Thorp, Anna Apanel, Steven Kramer, Chris Sims, David Karandish, Dean Aaron Bobick, Ralph Quatrano, John Zook and Alex Gray

Anna Apanel — Alumni Achievement Award
After Apanel earned a bachelor's degree in chemical engineering from Washington University in 1980, her early interest in computer modeling led her to modeling oil flow through rock miles beneath the Earth's surface. Apanel worked for ExxonMobil for 35 years, beginning as a reservoir engineer and expanding into oil field evaluation, economics and leadership. Being selected as a technical field studies consultant, she advised ExxonMobil affiliates worldwide on projects and studies, traveling to far parts of the world.

Alex Gray — Alumni Achievement Award
Gray is senior vice president of the customer services and support organization at Juniper Networks, which he joined in 2008. He is responsible for Juniper's technical assistance centers, its advanced and professional services portfolio, educational services and service supply chain, all of which contribute to a quarter of the company's annual revenue. After earning a bachelor's degree in 1979 and a master's degree in 1981, both in electrical engineering from Washington University, Gray worked for Hewlett-Packard. In 1987, Steve Jobs recruited Gray to lead NeXT Computer's growing information technology operations.

Steven Kramer — Alumni Achievement Award
As AECOM's vice president and tunneling business director, Kramer oversees the development and growth of the tunneling and trenchless practice in transportation, water and energy. Kramer has led the design, management and construction of more than 50 underground projects ranging in construction values up to $775 million for municipalities, utilities and transportation authorities in North America, Europe and Asia. Following the Sept. 11 attacks on the Pentagon, Kramer led a team on a project to construct a tunnel delivering water to the Pentagon's heating and cooling plant. Kramer earned bachelor's degrees in both engineering and public policy and civil engineering at WashU in 1982.

John Zook — Young Alumni Award
As vice president of engineering for Socrata, a startup developing cloud-based solutions for government agencies, Zook has a passion for finding unique insights as a data-focused engineering executive. The Socrata team delivers data-driven innovation and cost savings for public sector leaders and millions of their constituents around the world. Hundreds of governments and governmental agencies use the Socrata platform, including The White House, Centers for Medicare & Medicaid Services and the State of Missouri. Prior to starting Socrata, Zook worked for Amazon as a summer intern while a computer science student at WashU. That internship led to a permanent position with Amazon after earning his degree in 2004. He has been involved with several other successful startups since 2011.

David Karandish and Chris Sims — Engineering Entrepreneurship Award
As undergraduates in computer science with minors in entrepreneurial studies, Karandish and Sims began working on Internet marketing with search engine optimization consulting. In 2003, Karandish and Sims launched Expo Group, an online resource in the consumer financial services industry. After selling the company, they developed a relationship with Yahoo to launch findstuff.com. Later, Karandish and Sims diverged into other categories through parent company Announce Media/AFCV Holdings, a portfolio company of growth equity investors that eventually acquired Answers.com in 2011.

The Engineering Entrepreneurship Award, new in 2016, was established by the school to recognize entrepreneurs who advance creativity and innovation. These accomplishments should achieve economic and social development objectives that are relevant to the economy now and in the future.

Ralph Quatrano — Dean's Award
Ralph Quatrano came to WashU in 1998 as chair of the Department of Biology and the Spencer T. Olin Professor. He also was director of the Division of Biology & Biomedical Sciences from 2005 to 2007 and was named interim dean of the faculty of Arts & Sciences in 2008. Internationally known for his research in plant science, Quatrano applied the tools of molecular biology toward understanding the genetic regulatory mechanisms in plants. In 2010, Quatrano was named dean of the School of Engineering & Applied Science. He led the hiring of a third of the present faculty, including two new department chairs, and was a passionate proponent of interdisciplinary programs, while overseeing construction of two new engineering buildings.

code

Written by **RON CYTRON**
Associate Department Chair and Professor of Computer Science & Engineering

Most universities report a dramatic increase in students studying computer science. At Washington University, we offer CSE 131 as the introduction to computer science. Ten years ago, that course might interest 150 students per year. During the past calendar year, more than 1,000 students have completed the course, now the most enrolled course at WashU. With the help of faculty and students, we redesigned CSE 131 in 2010 to emphasize collaboration and applying computer science ideas and "thinking" to academic disciplines across our university. More recently, the course lectures were transformed into videos and exercises that faculty and students both say teach the material more efficiently and effectively.

But interest in that course cannot be attributed solely to improved pedagogy. There is a recognition across all disciplines that computer science is a powerful partner for academic studies, for professional practice and for enabling the advances we seek in our lives. Students appreciate how computer science studies cause them to "think differently": the application of logic to solve problems and the ability to automate what would otherwise be tasks that are tedious at best, and perhaps impossible without such automation.

Employment in the technology sector is strong with a forecast of even greater demand compared with supply. LaunchCode, a nonprofit organization, wants to solve that challenge and was recognized by the White House as a model for solving the nation's tech talent gap. Founded by St. Louis native and alumnus Jim McKelvey, LaunchCode had offered Harvard's CS50X course as the introductory experience — until now. This summer, LaunchCode will pilot Washington University's CSE 131 course for its adult students in what it's calling the Summer of Code. We believe it offers a stronger foundation for building skills in the adult student community, and its current formulation is particularly appealing for adults who cannot be full-time students. The lecture portions can be accomplished at students' convenience through the videos and exercises.

But as with WashU students, these adults will meet each week to work on problems collaboratively. In this way, they not only help each other learn the material, they also experience the collaborative nature of our discipline as it is practiced in the workplace. Students from Computer Science & Engineering have been mentoring adults in the LaunchCode program for the past semester, and they are a crucial component of the course's success. More undergraduate students than ever are finishing our introductory course intending to seek a minor or major in computer science. We hope adult students in the LaunchCode version of CSE 131 experience this same connection.

This partnership with LaunchCode has been exciting for the School of Engineering & Applied Science. We have been preparing assignments that are intended to be of interest to the LaunchCode students and more relevant to the tasks they would face in their apprenticeships. This program has the potential to improve the lives of the LaunchCode students and to create a larger base of computer science talent in our community. We hope that our school and department — its faculty, students and research — can be an ever more attractive resource for efforts such as LaunchCode, and we are proud to be a partner in its program.

Watch for the Fall 2016 issue of Engineering Momentum*, which will include a feature on the success of the Summer of Code and LaunchCode's overall impact in the St. Louis community.*

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#WashUengineers:

$$p = mv$$

Snapshot //

Sam Altman (right), president of Y Combinator, spoke to a packed room of WashU students about what it's really like to run a startup.

WHITNEY CURTIS